COVID-19 and Vaccination of Children and Adolescents: Prospects and Challenges

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Abbreviations:

COVID-19, Coronavirus disease 2019

NPI, Non-pharmaceutical interventions

SARS-CoV-2, Severe acute respiratory syndrome coronavirus 2019

FDA, Food and Drug Administration

CDC, Centers for Disease Control and Prevention

ACIP, Advisory Committee on Immunization Practices

NASEM, National Academies of Sciences Engineering and Medicine

HPV, Human papillomavirus

HIV, Human immunodeficiency virus

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The ongoing coronavirus disease 2019 (COVID-19) pandemic has caused over 1,000,000 deaths worldwide and over 200,000 deaths in the U.S to date.[1] Most, but not all of the deaths and more severe consequences of COVID-19 have been among older individuals.[2] However, in addition to the direct morbidity and mortality figures, there have been enormous disruptions in the lives of persons of all ages, with attendant emotional, economic, and social stresses.[3, 4] Approaches to managing the pandemic have relied upon what are referred to as non-pharmaceutical interventions (NPI), such as social distancing, wearing masks, washing hands, and testing and contact tracing. These approaches can be effective at mitigating the damage caused by COVID-19, but only if they are widely accepted and implemented, which has generally not been the case in the U.S. NPI often are characterized as stop-gap measures, "until a vaccine or cure is available." In fact, there have been unprecedented efforts to develop vaccines to prevent infection due to the severe acute respiratory syndrome coronavirus (SARS-CoV-2), the virus that causes COVID-19. As of the writing of this paper (October 2020), there were 44 candidate vaccines in human clinical trials, with 11 in phase 3 trials.[5] As a result, there is great expectation that a vaccine soon will be available. However, vaccination, like NPI, will not be effective without well-designed public health policies, clear public health communication, and widespread acceptance among the population. Also, we do not yet know how efficacious a vaccine will be or how long vaccine-induced immunity will last, including whether vaccination will need to be on a seasonal basis, like influenza vaccination. In addition, it is essential that a plan is in place for equitable allocation of any vaccine that becomes available, including for children and adolescents, to ensure that all are protected and that existing COVID-19 health disparities are not made worse.[6]

There are two steps to bringing any vaccine to use in the U.S, ie, licensure and recommendations for use. The first is the purview of the U.S. Food and Drug Administration (FDA) and the second is that of the Centers for Disease Control and Prevention (CDC). In the case of a SARS-CoV-2 vaccine that is found to be immunogenic, safe and efficacious in phase 3 trials, and considering the

urgent need for a lifesaving vaccine, the FDA first might give emergency use authorization (EUA), with licensure pending later results of additional requested/required data. Following EUA and/or licensure, the CDC, through the Advisory Committee on Immunization Practices (ACIP), considers the specifics of the vaccine's performance in trials, burden of disease and public health issues to recommend the specifics of the vaccine's use in the U.S. population and prioritization.

In this commentary, we address the prospects of a SARS-CoV-2 vaccine for the pediatric population, including discussions of the rationale for vaccinating minors, the challenges involved, the potential impact on acceptability of other vaccines, and reasons for moderating the uncritical optimism that a vaccine for children or adults, by itself, will solve our COVID-19 pandemic problems.

***What is the rationale for vaccinating minor children and* adolescents?**

Morbidity and mortality associated with SARS-CoV-2 infection are significantly lower in young children and in adolescents, and children may be less susceptible to infection.[7] However, there have been reports of COVID-19 disease symptoms, some severe, and some instances of death in children and adolescents. As of October, 2020, the American Academy of Pediatrics reported that nearly 700,000 child and adolescent COVID-19 cases had been reported in the U.S. (10.7% of all cases), with over 5,000 cumulative hospitalizations and over 100 deaths.[8] These numbers pale compared with cases, hospitalizations, and deaths among individuals aged 65 years and older (e.g., as of October 14, there were over 160,000 cumulative deaths in this age group).[2] Therefore, vaccination of older adults has significantly more potential direct benefit than vaccination of children. However, there are additional factors to consider.

Although most vaccines provide direct personal health benefits, the primary public health goal of vaccination is herd immunity. The key question, then, is: are children vectors of transmission to more vulnerable adults? Increasingly, the evidence suggests that infected children and adolescents can infect other children and adults.[9-12] To protect society as a whole, including older adults, and to decrease

household transmission of SARS-CoV-2, it may make sense to vaccinate children and adolescents, as well as adults. An additional factor is that the childhood and adolescent vaccination infrastructure is very well developed in the U.S., so that it should be possible to integrate new SARS-CoV-2 vaccines into existing immunization platforms.

The CDC, National Academies of Sciences Engineering and Medicine (NASEM), and Johns Hopkins Center for Health Security all consider adults working as teachers and staff in K-12 schools and in out-of-home childcare settings to be critical populations needed to maintain core societal functions and should receive prioritized access to SARS-CoV-2 vaccines when supplies are limited. None of their allocation frameworks considers minor children as a high priority group.[6, 13, 14] One could argue that part of protecting teacher and staff working in K-12 schools would be to also prioritize vaccination of students.

When will a SARS-CoV-2 vaccine be available for children and adolescents?

Up until mid-October, 2020, no minors had been enrolled in any SARS-CoV-2 vaccine clinical trials.[15] However, some researchers and groups, including the American Academy of Pediatrics, have called for clinical trials with minor adolescents to begin as soon as possible.[16, 17] In fact, one of the pharmaceutical companies with a candidate SARS-CoV-2 vaccine in phase 3 clinical trials with adults was approved by the FDA to begin enrollment of children down to age 12 years,[18] and reportedly had enrolled 100 children aged 12-15 years and 200 children aged 16-17 years by the end of October 2020.[19] It is not clear, however, how rapidly they will be able to continue enrolling children and minor adolescents into this clinical trial and we are not aware of any research that has examined parental and child willingness to participate in SARS-CoV-2 vaccine clinical trials. Historically, the typical course of research would be to conclusively demonstrate efficacy and safety in adults, then do immune-bridging studies in younger adolescents and children, which was the approach undertaken for human papillomavirus (HPV) vaccine.[20] The process of developing and testing SARS-CoV-2 vaccines has been

accelerated significantly by enacting steps simultaneously, rather than sequentially.[21] Moreover, the bioethical and procedural infrastructures for ethical conduct and implementation of vaccine prevention trials are under-developed for minors. The process of ensuring ethical conduct of vaccine prevention trials for minors is complex and uncertain, particularly in the context of incomplete data about potential individual benefit and safety. Lessons from trials of HPV vaccines, as well as consideration of trials for potential human immunodeficiency virus (HIV) vaccines,[22, 23] provide sound basis for SARS-CoV-2 vaccine research. The process could be additionally supported by detailed guidance in considering topics such as community benefits, diverse racial/ethnic enrollment, youths' vulnerability, preventive misconception, as well as the operationalization of informed, shared youth-parent decision-making and assent/consent.[24, 25]

Even in the most optimistic of circumstances, if SARS-CoV-2 vaccine development and FDA's EUA/licensure and ACIP's recommendations follow the same general course as previous vaccine trials, it is unlikely that a large enough number of minors could be enrolled in such studies before early- to mid-2021. In addition, getting vaccine EUA/licensure and recommendations for minors may be a lengthier process than for adults, and recommendations for implementation and prioritization will be complex, making it unlikely that a vaccine for minors would be available before 2022.

Another issue is that vaccine trials focus on safety and efficacy in reducing the vaccinee's morbidity and mortality. They do not offer insight into how the vaccine might affect infectiousness. As noted in the NASEM publication, *Framework for Equitable Allocation of COVID-19 Vaccine*, "The ongoing COVID-19 vaccine trials are not designed to estimate the impact of the vaccine candidates on transmission and evidence of the vaccines' actual impact on transmission might not be available for some time after FDA approval."(Section S-6)[6] Given that the primary goal of vaccinating children and adolescents would be reduction in transmission of SARS-CoV-2 to older adults, determining the impact of candidate vaccines on infectiousness will be essential.

At the core of efforts to first recruit minors into vaccine trials and hopefully participate in SARS-CoV-2 vaccination programs lies the need to restore and expand widespread belief in the trustworthiness of scientific and public health authorities. Erosion of trust in these authorities' perspectives on vaccination research and vaccination began well before the ongoing COVID-19 pandemic,[26] but has been accentuated during this pandemic.[27, 28] Marked disparities in SARS-CoV-2 transmission and mortality, as well as politization of public health implementation of NPI, contribute to the difficulties to be faced in developing and implementing policy for use of a vaccine licensed by the FDA (or with FDA's EUA) and recommended by ACIP for children and adolescents. This is an important issue for adolescents, as many have adopted skeptical perspectives on vaccine research and vaccination, based in larger societal issues of pervasive racism and discrimination, medical mistrust, and systematic misinformation programs addressed to social media platforms widely used by young people.[29, 30]

Do we have to wait for vaccine availability to move towards a more normal, pre-COVID-19 lifestyle?

We currently have tools to limit the spread of SARS-CoV-2, including wearing masks, social distancing, handwashing, testing and tracing, and isolating those who test positive or who have had close contact with others who have tested positive. Although widespread, long-term implementation of NPI protocols during the pandemic has introduced an array of sociocultural and developmental risks for children and adolescents (NASEM, page 1-15),[6] these kind of approaches appeared to be quite effective at protecting children from infection at summer camps in Maine,[31] which implemented comprehensive NPI, compared with a summer camp in Georgia,[10] which did not.

One challenge is that NPI have been implemented inconsistently and have become politically polarized.[32] However, there is reason to believe that the same will be true for any SARS-CoV-2 vaccine. Research shows that those who identify as conservative have lower intent to get a vaccine than those who identify as liberal.[33, 34] Also, a recent Axios-Ipsos poll indicated that only 39% of adults polled would get a COVID-19 vaccine as soon as it is available (43% of Democrats; 33% of Republicans).[35] We need

national and local strategies to promote both NPI and future vaccines and to overcome the significant attitudinal barriers, including with respect to NPI and vaccines for children. As noted by Danchin et al, "To build vaccine confidence in general practice, governments need to invest in understanding the factors that will influence COVID-19 vaccine acceptance and plan to co-design strategies with communities to optimise uptake when these vaccines become available" (p. 628).[36] We also clearly need to implement such national and community-based strategies based in expanded understanding of neurocognitive development in adolescence, and in leveraging technology to promote health-serving behaviors such as vaccination.[37, 38]

Effective communication about SARS-CoV-2 vaccines also is important in order to maintain confidence in, and acceptability of, other pediatric and adolescent vaccines. This is particularly important given the significant disruptions in routine childhood and adolescent vaccination delivery due to the COVID-19 pandemic.[39-41] Failures to adequately explain how efficacy of SARS-CoV-2 vaccines will be evaluated and safety ensured, including potential limited efficacy, could result in heightened public hesitancy about vaccination in general. It is encouraging that a recent study found increased parental intent to vaccinate children against influenza due to the COVID-19 pandemic.[42] However, we need to remain vigilant about the potential for public skepticism about SARS-CoV-2 vaccination to spill over to childhood and adolescent vaccines.

Will vaccine availability preclude the need for NPI?

"Until we have a vaccine, we have to rely on NPI to manage the pandemic". This sentence, or ones like this, which begin many COVID-19 articles related to NPI, harken back to behavioral research on HIV prevention. Many research articles started with a similar sentence in reference to controlling HIV and other sexually transmitted infections.[43] As noted in a commentary published in 2000,[43] it is a comment that confers second class status to NPI and implies that they will no longer be needed once a vaccine is developed and made available.

However, if used properly, NPI are very effective at controlling the spread of SARS-CoV-2 – in fact, possibly more effective than a vaccine with modest efficacy. Also, accepting and getting vaccinated is, in fact, a behavior. The development and availability of a safe and sufficiently efficacious vaccine will not ensure vaccine impact in the real world. This is a lesson we should have learned from HPV vaccination in the U.S., when, over 14 years since HPV vaccine was first licensed, the rate of series completion among adolescents is only 54.2%.[41] We remain far from the Healthy People 2020 goal of 80% HPV vaccine series completion.[44]

In addition, without clear communication about vaccine efficacy (or limitations of efficacy) and length of protection, there exists the potential for risk-compensation. That is, if behavioral/social (NPI) mitigation efforts are substantially decreased due to reduced concerns about infection once a vaccine or vaccines are licensed by the FDA or receive FDA's EUA and are recommended by ACIP, and vaccines have only modest efficacy and/or low uptake, then vaccine availability could have the perverse consequence of increasing rates of SARS-CoV-2 infection.

Similarly, the availability of a vaccine also may result in school and public authorities prematurely lifting NPI restrictions or reducing enforcement of such policies, again potentially leading to continued outbreaks of infection. Although risk-compensation is not an issue with HPV vaccination,[45] the intense desire to return to pre-COVID-19 lifestyles and/or to moderate NPI-related sociocultural and developmental impacts suggest that risk-compensation may become an issue with SARS-CoV-2 vaccines. It is essential, therefore, that public health authorities and health professionals begin now to communicate with patients and the public in general about the likelihood that behavioral mitigation strategies will continue to be needed even in the context of an approved SARS-CoV-2 vaccine.

Conclusion

There is a strong rationale for including children and adolescents in SARS-CoV-2 vaccine clinical trials and for including minors as important targets for vaccination, principally to protect older adults

with whom they interact, and achieve potential community protection. At the same time, it is essential that we temper the expectations that availability of one or more SARS-CoV-2 vaccines will allow children, adolescents, and adults to resume a normal, pre-COVID-19 life. The many uncertainties about COVID-19, about the efficacy and safety of candidate vaccines, and about the duration of vaccine-induced immunity make it particularly important that we are as clear as possible in our communications about COVID-19, potential vaccines, and the almost certain situation that NPI will still be needed for some time to come. Such clarity of communication at the national and community levels also will help to maintain confidence in other childhood and adolescent vaccines. The development and availability of SARS-CoV-2 vaccines will represent important steps in managing the COVID-19 pandemic, but they are likely one element in a multifaceted set of strategies that we will need to employ.

References

[1] Statista. Number of novel coronavirus (COVID-19) deaths worldwide as of October 12, 2020, by country. statista.com: Statista; 2020. https://www.statista.com/statistics/1093256/novel-coronavirus-2019ncov-deaths-worldwide-by-country/. Accessed October 15, 2020.

[2] Center for Disease Control and Prevention. Weekly updates by select demographic and geographic characteristics: Provisional death counts for coronavirus disease 2019 (COVID-19). https://www.cdc.gov/nchs/nvss/vsrr/covid_weekly/index.htm. Accessed October 15, 2020.

[3] Xiong J, Lipsitz O, Nasri F, Lui LMW, Gill H, Phan L, et al. Impact of COVID-19 pandemic on mental health in the general population: A systematic review. J Affect Disord. 2020;277:55-64.

[4] Sauer KS, Jungmann SM, Witthöft M. Emotional and behavioral consequences of the COVID-19 pandemic: The role of health anxiety, intolerance of uncertainty, and distress (in)tolerance. Int J Environ Res Public Health. 2020;17(19):E7241.

[5] Corum J, Wee S-L, Zimmer C. Coronavirus Vaccine Tracker. The New York Times; 2020. https://www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html. Accessed October 13, 2020.

[6] National Academies of Science, Engineering, and Medicine. Framework for Equitable Allocation of COVID-19 Vaccine. Washington, DC: The National Academies Press; 2020.

[7] Viner RM, Mytton OT, Bonell C, Melendez-Torres GJ, Ward J, Hudson L, et al. Susceptibility to SARS-CoV-2 infection among children and adolescents compared with adults: A systematic review and meta-analysis. JAMA Pediatr. 2020 [Epub ahead of print].

[8] American Academy of Pediatrics. Children and COVID-19: State-Level Data Report. 2020. https://services.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/children-and-covid-19-state-level-data-report/. Accessed October 14, 2020.

[9] Park YJ, Choe YJ, Park O, Park SY, Kim YM, Kim J, et al. Contact tracing during coronavirus disease outbreak, South Korea, 2020. Emerg Infect Dis. 2020;26(10):2465-8.

[10] Szablewski CM, Chang KT, Brown MM, Chu VT, Yousaf AR, Anyalechi N, et al. SARS-CoV-2 transmission and infection among attendees of an overnight camp - Georgia, June 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1023-5.

[11] Lopez AS, Hill M, Antezano J, Vilven D, Rutner T, Bogdanow L, et al. Transmission dynamics of COVID-19 outbreaks associated with child care facilities - Salt Lake City, Utah, April-July 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1319-23.

[12] Schwartz NG, Moorman AC, Makaretz A, Chang KT, Chu VT, Szablewski CM, et al. Adolescent with COVID-19 as the source of an outbreak at a 3-week family gathering - four states, June-July 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1457-9.

[13] Centers for Disease Control and Prevention. COVID-19 vaccination program interim playbook for jurisdiction operations. Version 1.0. 2020. https://www.cdc.gov/vaccines/imz-

managers/downloads/COVID-19-Vaccination-Program-Interim_Playbook.pdf. Accessed October 15, 2020.

[14] Toner E, Barnill A, Krubiner C, Bernstein J, Privor-Dumm L, Watson M, et al. Interim Framework for COVID-19 Vaccine Allocation and Distribution in the United States. Baltimore, MD: Johns Hopkins Center for Health Security; 2020.

[15] Anderson EJ, Campbell JD, Creech CB, Frenck R, Kamidani S, Munoz FM, et al. Warp speed for COVID-19 vaccines: Why are children stuck in neutral? Clin Infect Dis. 2020 [Epub ahead of print].

[16] Goza SH. AAP Letter to HHS and FDA on Children Participating in COVID-19 Vaccine Trials. American Academy of Pediatrics; 2020. https://downloads.aap.org/DOFA/AAPLettertoHHSandFDAChildreninCOVID19VaccineTrials.pdf. Accessed October 6, 2020.

[17] Downey KJ. Time to include children in COVID-19 vaccine trials, experts say. Healio.com: Healio News; 2020. https://www.healio.com/news/infectious-disease/20201004/time-to-include-children-in-covid19-vaccine-trials-experts-say. Accessed October 6, 2020.

[18] Aubrey A. Will Kids Get A COVID-19 Vaccine? Pfizer To Expand Trial To Ages 12 And Up. NPR; 2020. https://www.npr.org/sections/health-shots/2020/10/13/923248377/will-kids-get-a-covid-19-vaccine-pfizer-to-expand-trial-to-ages-12-and-up. Accessed October 13, 2020.

[19] Hohman M. Will kids or pregnant women be able to get a COVID-19 vaccine? Today.com; 2020. https://www.today.com/health/covid-19-vaccine-will-it-be-safe-kids-pregnant-women-t196352. Accessed October 30, 2020.

[20] Block SL, Nolan T, Sattler C, Barr E, Glacoletti KED, Marchant CD, et al. Comparison of the immunogenicity and reactogenicity of a prophylactic quadrivalent human papillomavirus (Types 6, 11, 16, and 18) L1 virus-like particle vaccine in male and female adolescents and young adult women. Pediatrics. 2006;118:2135-45.

[21] Department of Health and Human Services. Fact Sheet: Explaining Operation Warp Speed. 2020. https://www.hhs.gov/coronavirus/explaining-operation-warp-speed/index.html. Accessed October 15, 2020.

[22] Bass SB, D'Avanzo P, Alhajji M, Ventriglia N, Trainor A, Maurer L, et al. Exploring the engagement of racial and ethnic minorities in HIV treatment and vaccine clinical trials: A scoping review of literature and implications for future research. AIDS Patient Care STDS. 2020;34:399-416.

[23] Braun-Courville DK, Schlecht NF, Burk RD, Strickler HD, Rojas M, Lorde-Rollins E, et al. Strategies for conducting adolescent health research in the clinical setting: the Mount Sinai Adolescent Health Center HPV experience. J Pediatr Adolesc Gynecol. 2014;27:e103-8.

[24] Robertson EG, Wakefield CE, Signorelli C, Cohn RJ, Patenaude A, Foster C, et al. Strategies to facilitate shared decision-making about pediatric oncology clinical trial enrollment: A systematic review. Patient Educ Couns. 2018;101:1157-74.

[25] Lally M, Goldsworthy R, Sarr M, Kahn J, Brown L, Peralta L, et al. Evaluation of an intervention among adolescents to reduce preventive misconception in HIV vaccine clinical trials. J Adolesc Health. 2014;55:254-9.

[26] Scharff DP, Mathews KJ, Jackson P, Hoffsuemmer J, Martin E, Edwards D. More than Tuskegee: understanding mistrust about research participation. J Health Care Poor Underserved. 2010;21:879-97.

[27] Kreps SE, Kriner DL. Model uncertainty, political contestation, and public trust in science: Evidence from the COVID-19 pandemic. Sci Adv. 2020 [Epub ahead of print].

[28] Romer D, Jamieson KH. Conspiracy theories as barriers to controlling the spread of COVID-19 in the U.S. Soc Sci Med. 2020:113356.

[29] Bogart LM, Ransome Y, Allen W, Higgins-Biddle M, Ojikutu BO. HIV-related medical mistrust, HIV testing, and HIV risk in the National Survey on HIV in the Black community. Behav Med. 2019;45:134-42.

[30] Earnshaw VA, Bogart LM, Klompas M, Katz IT. Medical mistrust in the context of Ebola: Implications for intended care-seeking and quarantine policy support in the United States. J Health Psychol. 2019;24:219-28.

[31] Blaisdell LL, Cohn W, Pavell JR, Rubin DS, Vergales JE. Preventing and mitigating SARS-CoV-2 transmission - Four overnight camps, Maine, June-August 2020. MMWR Morb Mortal Wkly Rep. 2020;69:1216-20.

[32] Kasting ML, Head KJ, Hartsock JA, Sturm L, Zimet GD. Public perceptions of the effectiveness of recommended non-pharmaceutical intervention behaviors to mitigate the spread of SARS-CoV-2. PLoS One [in press].

[33] Reiter P, Pennell M, Katz M. Acceptability of a COVID-19 vaccine among adults in the United States: How many people would get vaccinated? Vaccine. 2020;38:6500-7.

[34] Head KJ, Kasting ML, Sturm LA, Hartsock JA, Zimet GD. A national survey assessing SARS-CoV-2 vaccination intentions: Implications for future public health communication efforts. Science Commun. 2020;42:698-723.

[35] Talev M. Axios-Ipsos poll: Vaccine resistance grows. axios.com: Axios; 2020. https://www.axios.com/axios-ipsos-poll-coronavirus-index-vaccine-doubts-e9205f29-8c18-4980-b920-a25b81eebd84.html. Accessed October 15, 2020.

[36] Danchin M, Biezen R, Manski-Nankervis J, Kaufman J, Leask J. Preparing the public for COVID 19 vaccines. Australian Journal for General Practitioners. 2020;49:625-9.

[37] Giovanelli A, Ozer EM, Dahl RE. Leveraging technology to improve health in adolescence: A developmental science perspective. J Adolesc Health. 2020;67:s7-s13.

[38] Odgers CL. Why digital tools have not yet revolutionized adolescent health research and what we can do. J Res Adolesc. 2019;29:675-81.

[39] Nelson R. COVID-19 disrupts vaccine delivery. Lancet Infect Dis. 2020;20:546.

[40] Santoli JM, Lindley MC, DeSilva MB, Kharbanda EO, Daley MF, Gallloway L, et al. Effects of the COVID-19 pandemic on routine pediatric vaccine ordering and administration—United States, 2020. MMWR Morbidity and Mortality Weekly Report. 2020;69:591-3.

[41] Elam-Evans LD, Yankey D, Singleton JA, Sterrett N, Markowitz LE, Williams CL, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13-17 Years - United States, 2019. MMWR Morb Mortal Wkly Rep. 2020;69:1109-16.

[42] Goldman RD, McGregor S, Marneni SR, Katsuta T, Griffiths MA, Hall JE, et al. Willingness to vaccinate children against influenza after the COVID-19 pandemic. J Pediatr. 2020 [Epub ahead of print].

[43] Zimet GD, Mays RM, Fortenberry JD. Vaccines against sexually transmitted infections: Promise and problems of the magic bullets for prevention and control. Sex Transm Dis. 2000;27:49-52.

[44] U.S. Department of Health and Human Services. Healthy People 2020. Office of Disease Prevention and Health Promotion; 2015. http://www.healthypeople.gov/2020/topics-objectives/topic/immunization-and-infectious-diseases/objectives. Accessed October 3, 2020.

[45] Kasting ML, Shapiro GK, Rosberger Z, Kahn JA, Zimet GD. Tempest in a teapot: A systematic review of HPV vaccination and risk compensation research. Hum Vaccin Immunother. 2016;12:1435-50.